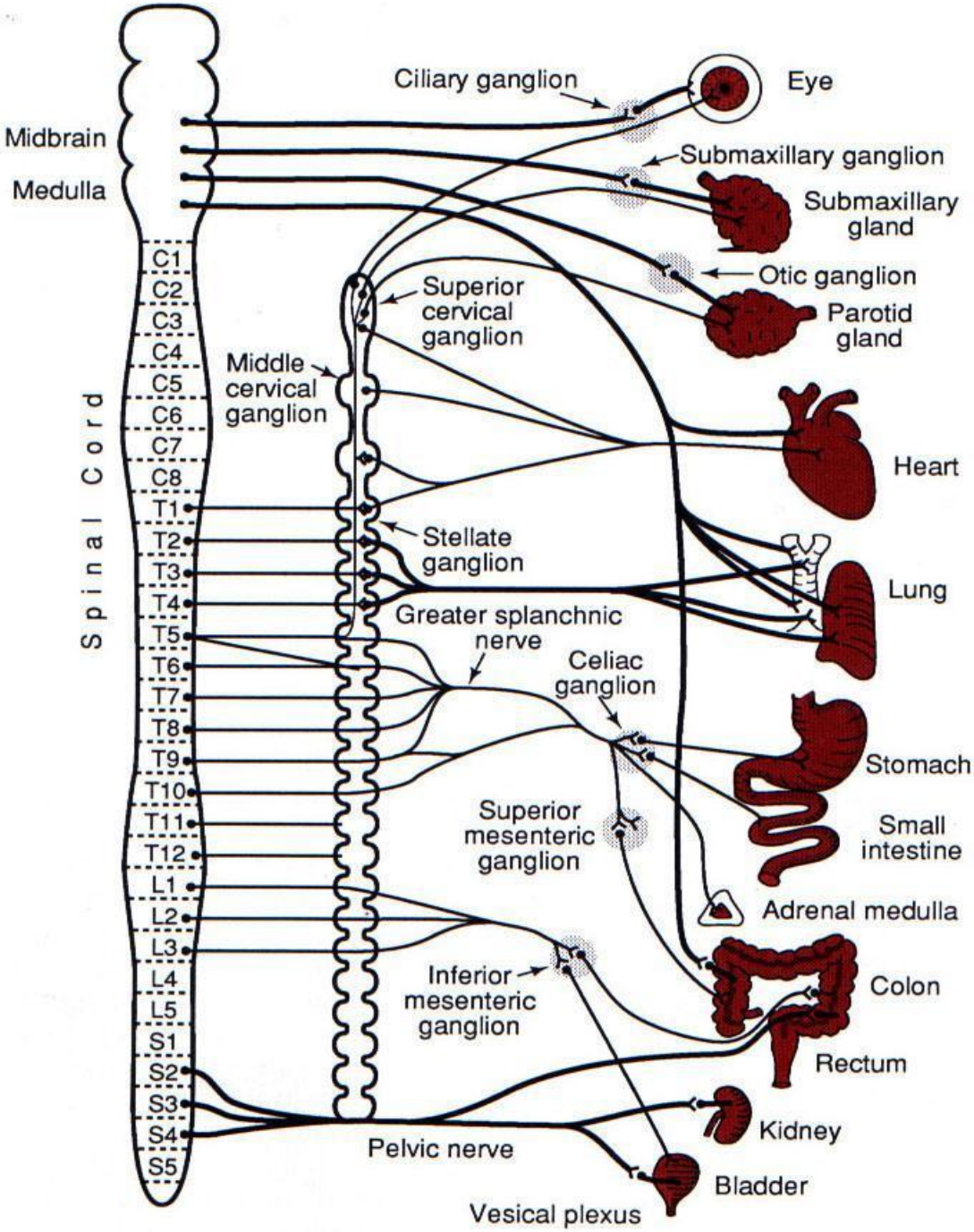
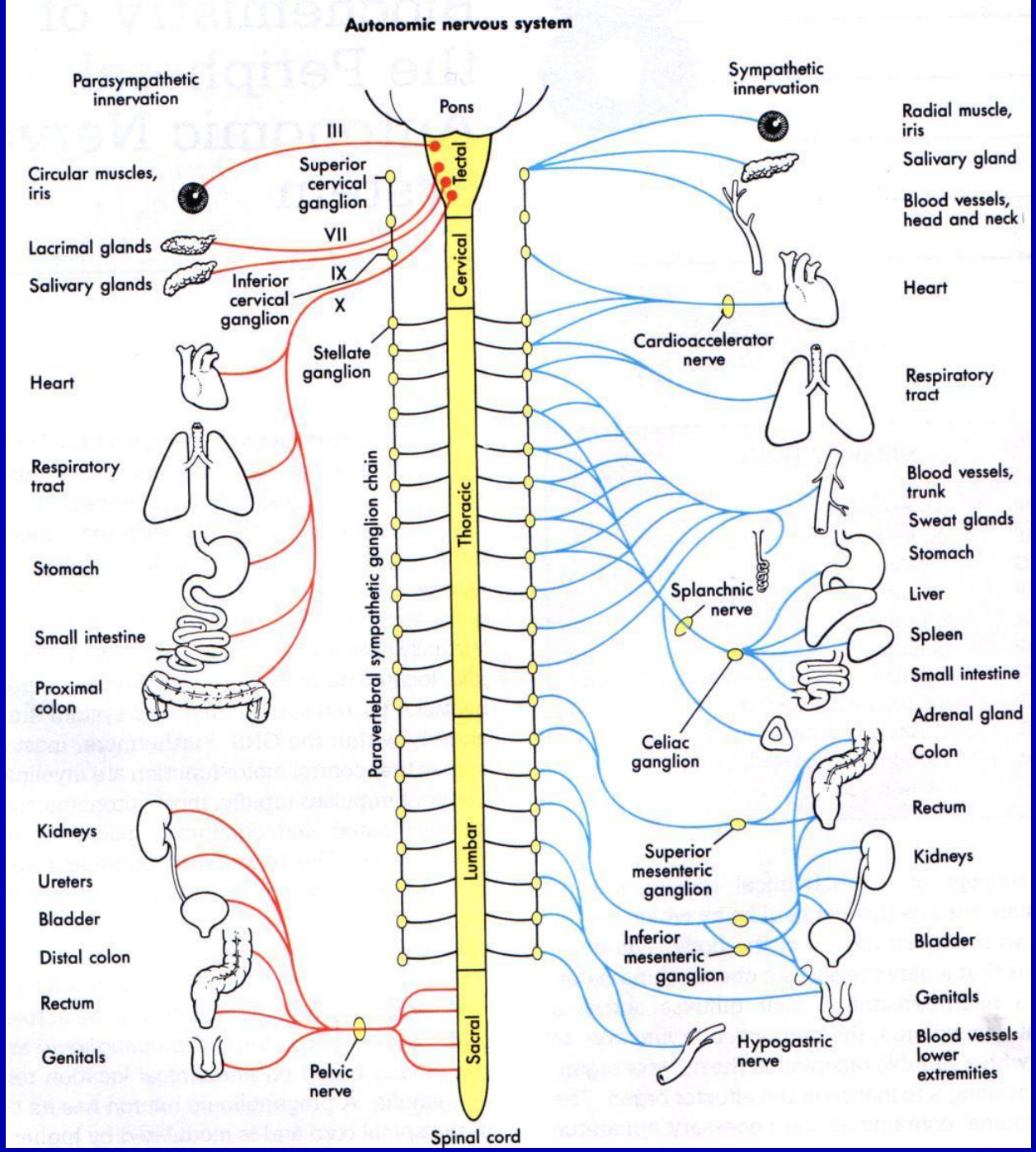


FIG. 1. Peripheral organization of the efferent pathways of the sympathetic and parasympathetic subsystems of the autonomic nervous system. Parasympathetic efferent pathways are denoted by *bold lines*, whereas sympathetic efferent pathways are illustrated by *thin lines*.


Autonomic nervous system
Parasympathetic innervation
Sympathetic innervation
Pons
III
VII
IX
X
Tectal
Cervical
Thoracic
Lumbar
Sacral
Superior cervical ganglion
Inferior cervical ganglion
Stellate ganglion
Paravertebral sympathetic ganglion chain
Circular muscles, iris
Lacrimal glands
Salivary glands
Heart
Respiratory tract
Stomach
Small intestine
Proximal colon
Kidneys
Ureters
Bladder
Distal colon
Rectum
Genitals
Pelvic nerve
Spinal cord
Radial muscle, iris
Salivary gland
Blood vessels, head and neck
Heart
Cardioaccelerator nerve
Respiratory tract
Blood vessels, trunk
Sweat glands
Stomach
Liver
Splanchnic nerve
Spleen
Small intestine
Adrenal gland
Celiac ganglion
Colon
Rectum
Superior mesenteric ganglion
Kidneys
Inferior mesenteric ganglion
Bladder
Genitals
Hypogastric nerve
Blood vessels lower extremities

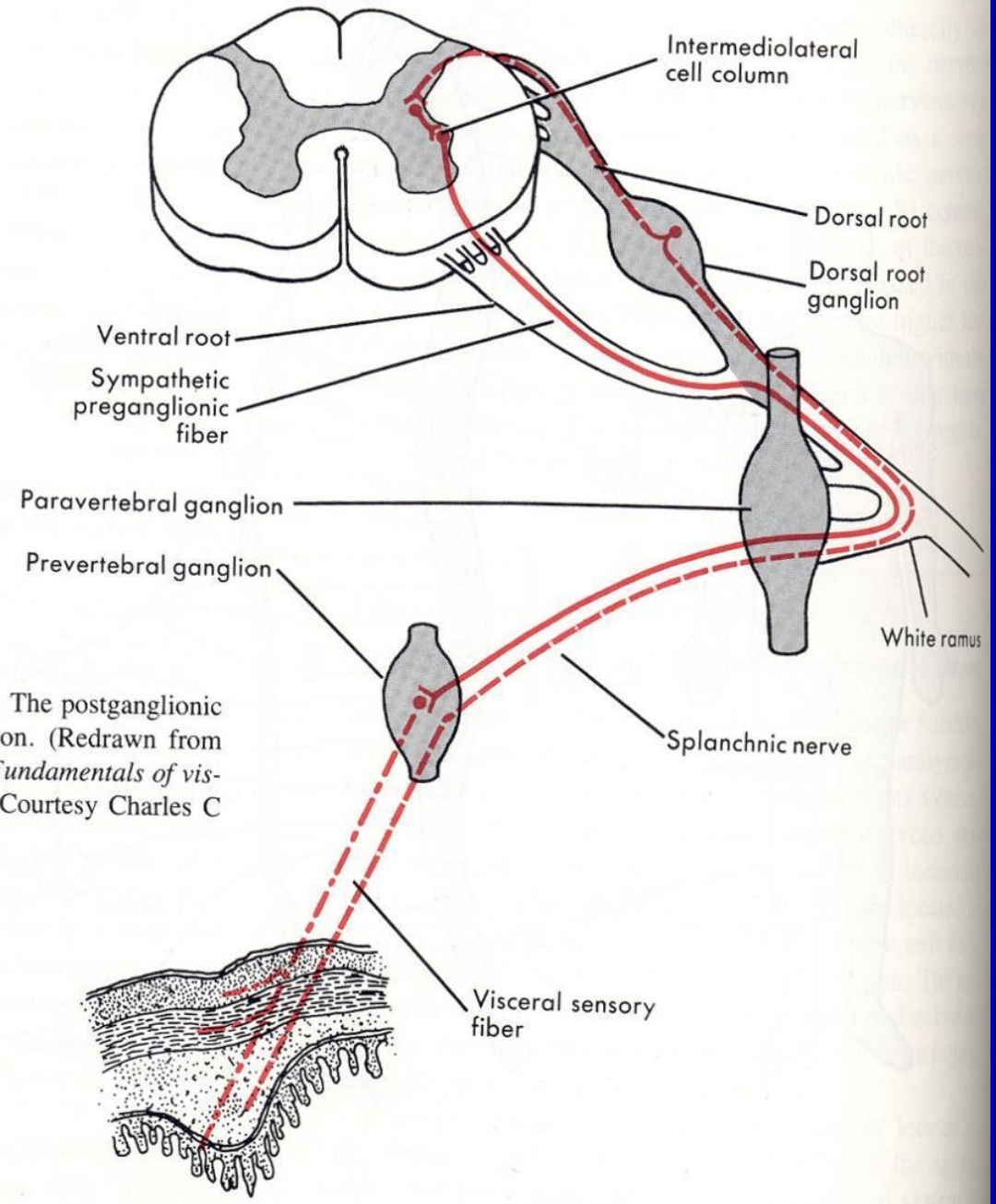


Fig. 15-2 Simple visceral reflex arc. The postganglionic neuron is shown in a prevertebral ganglion. (Redrawn from Bhagat BD, Young PA, Biggerstaff DE: *Fundamentals of visceral innervation,* 1977, Springfield, Ill, Courtesy Charles C Thomas.)

НЕРВНАЯ РЕГУЛЯЦИЯ

1906
1932
1936
1938
1944
1949 (a)
1963
1970
1973
1981 (a)
2000

ГЕНРИ ХОЛЛЕТ **ДЕЙЛ**, Великобритания
(Sir HENRY HALLETT DALE)
1875-1968

ОТТО **ЛЁВИ**, Австрия
(OTTO LOEWI)
1873-1961

ФОРМУЛИРОВКА НОБЕЛЕВСКОГО КОМИТЕТА: «за открытия, связанные с химической передачей нервных импульсов».

СУТЬ ОТКРЫТИЯ: за открытие факта химической передачи в синапсах нервной системы и, в частности, за описание роли ацетилхолина в этом процессе.

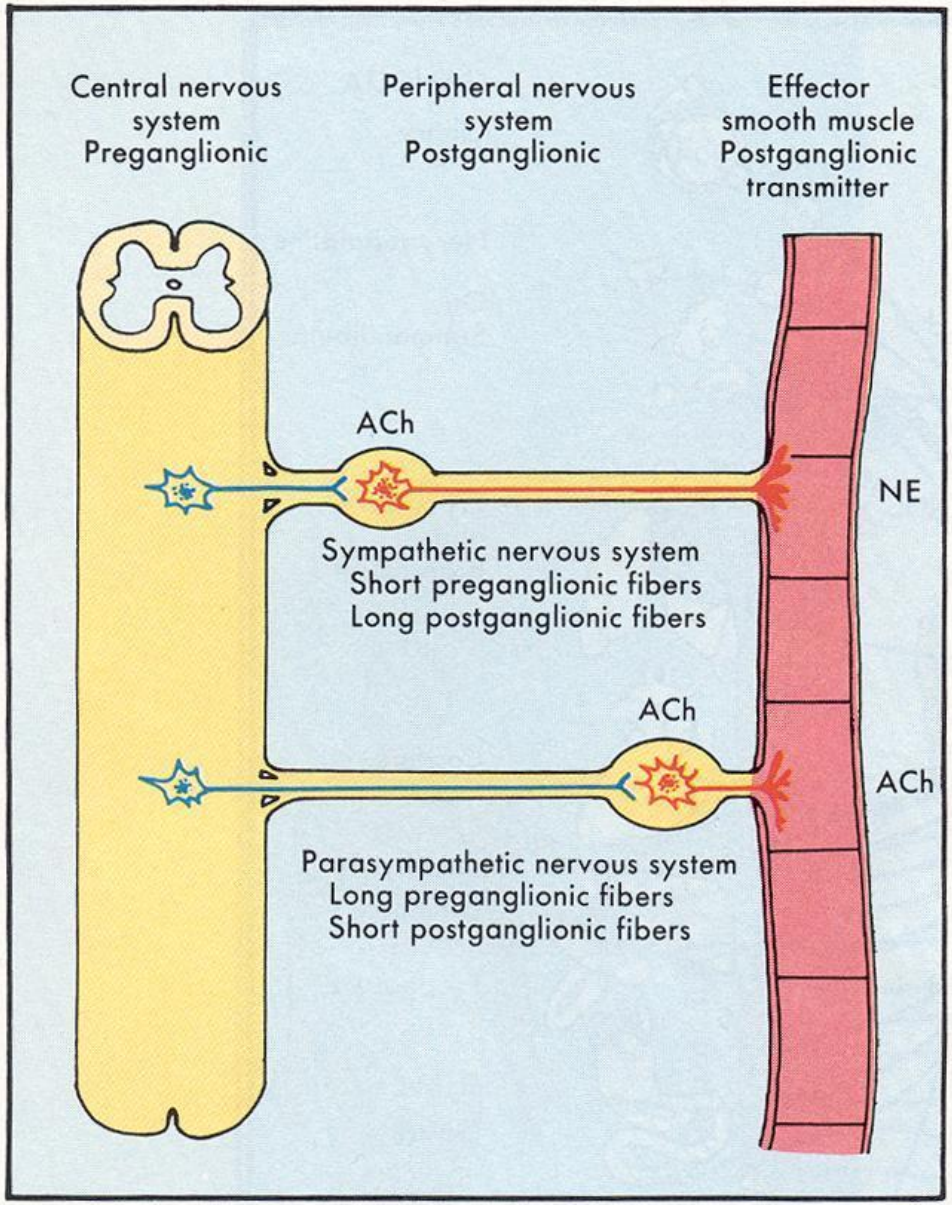


FIGURE 9-4 Transmitters of autonomic ganglia and postganglionic synapses. *Ach*, Acetylcholine.

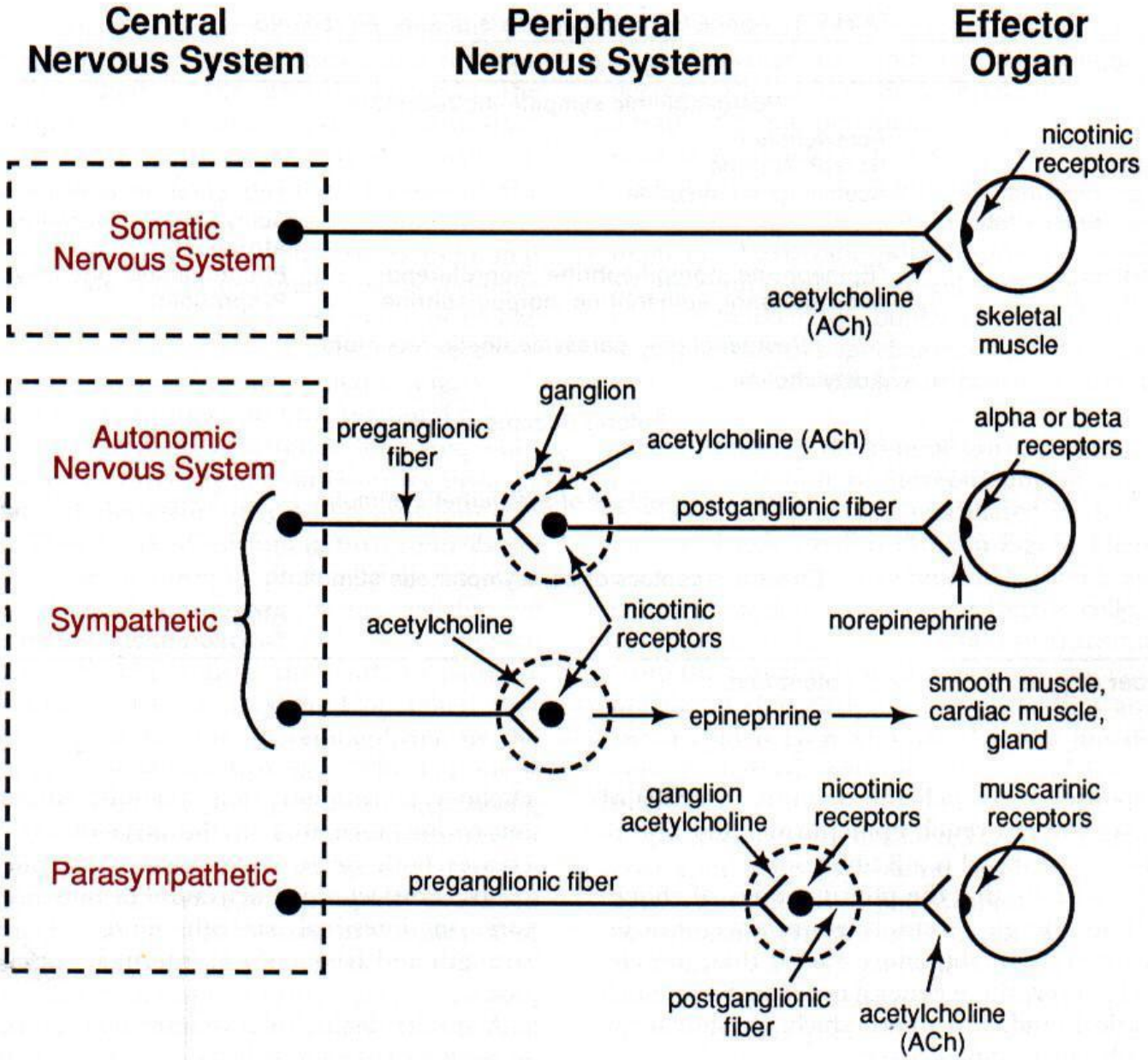
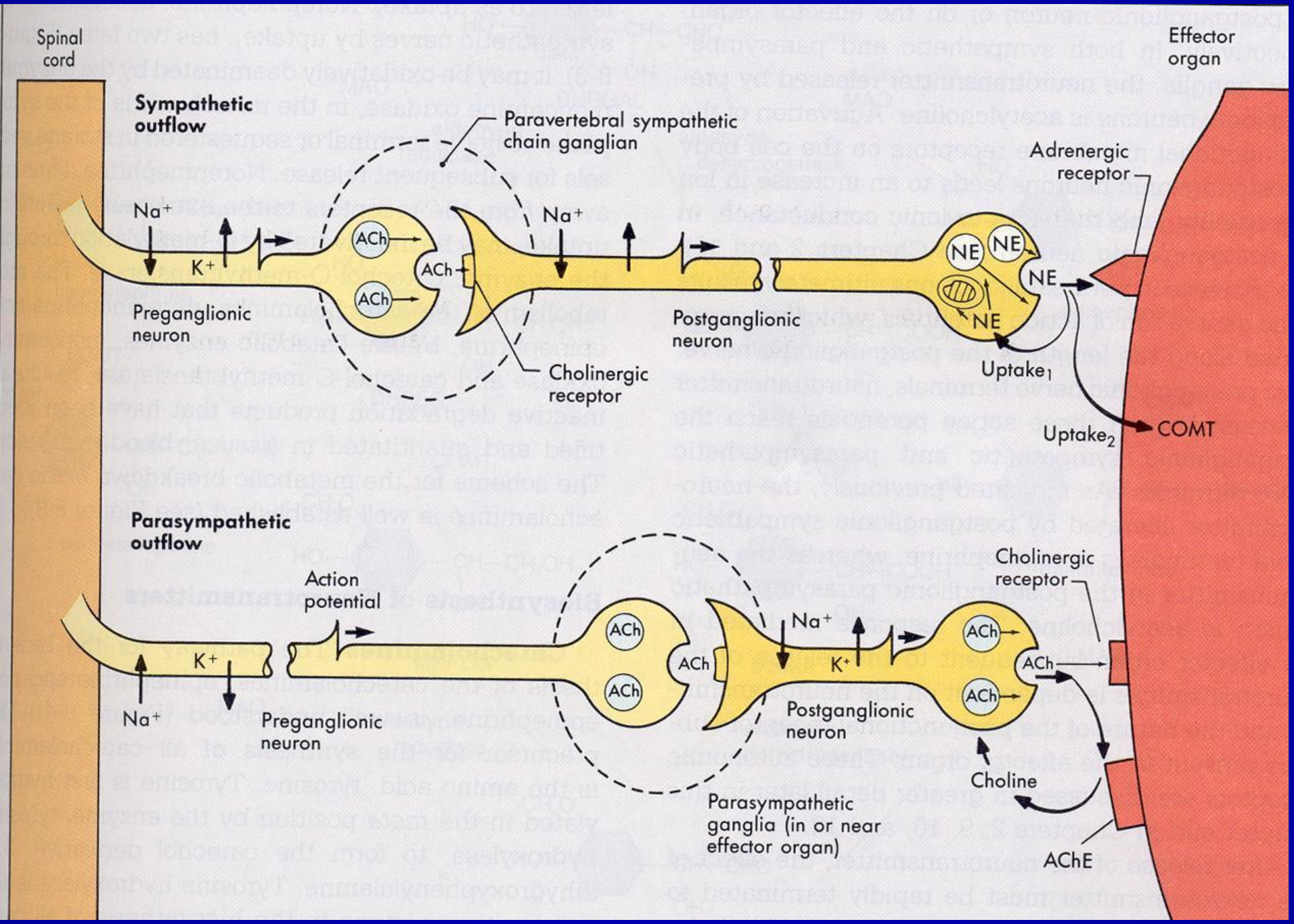


FIG. 3. Conceptual overview of synaptic mechanisms in peripheral pathways of the somatic, sympathetic, and parasympathetic neural subsystems.


Spinal cord
Effector organ
Sympathetic outflow
Paravertebral sympathetic chain ganglian
Adrenergic receptor
Na+
K+
ACh
ACh
ACh
Na+
NE
NE
NE
NE
Preganglionic neuron
Postganglionic neuron
Cholinergic receptor
Uptake1
Uptake2
COMT
Parasympathetic outflow
Action potential
Cholinergic receptor
K+
Na+
ACh
ACh
ACh
Na+
K+
ACh
ACh
Preganglionic neuron
Postganglionic neuron
Choline
Parasympathetic ganglia (in or near effector organ)
AChE

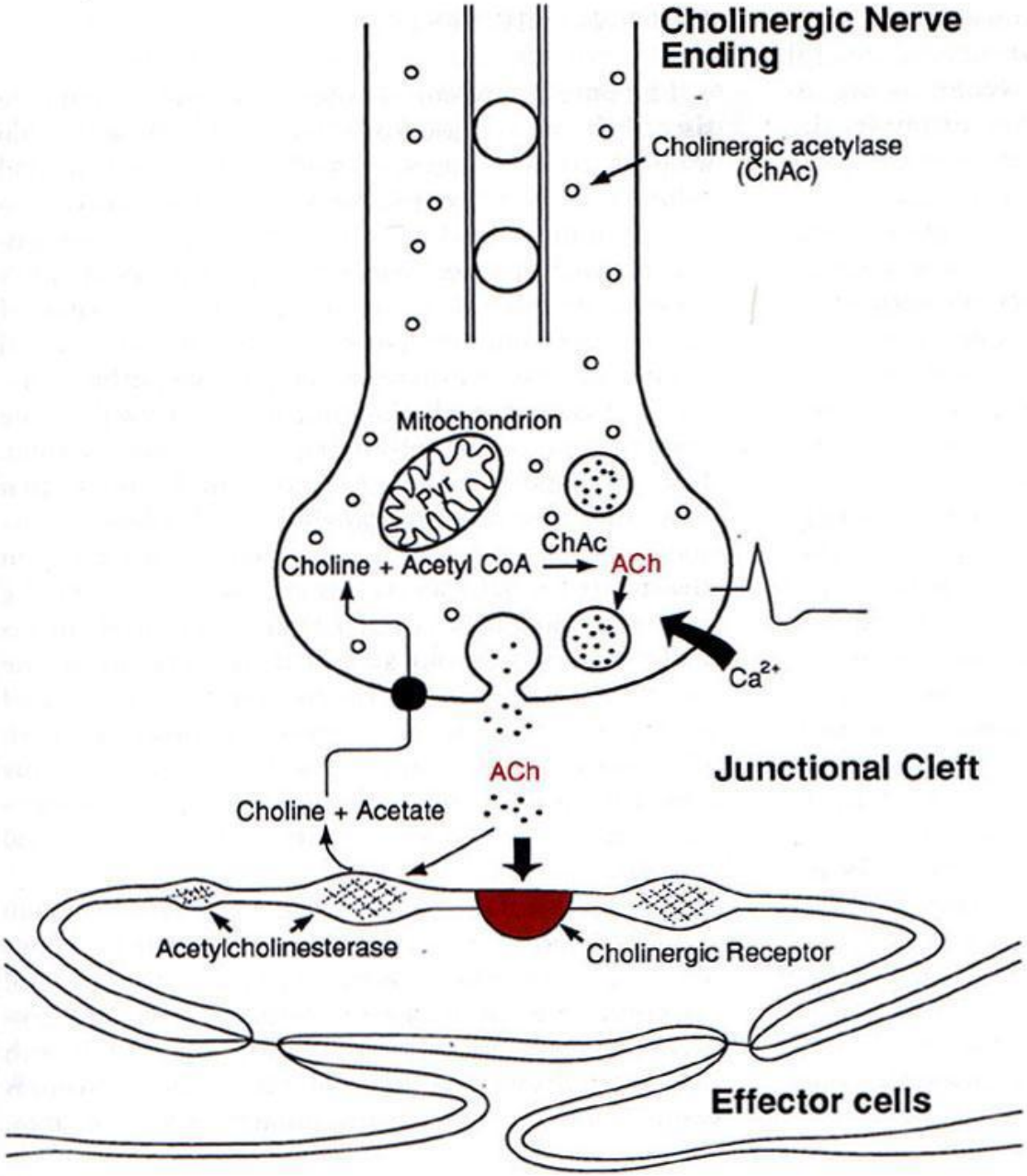


FIG. 7. Synthesis and exocytotic release of acetylcholine from the bouton of parasympathetic post-ganglionic axon.

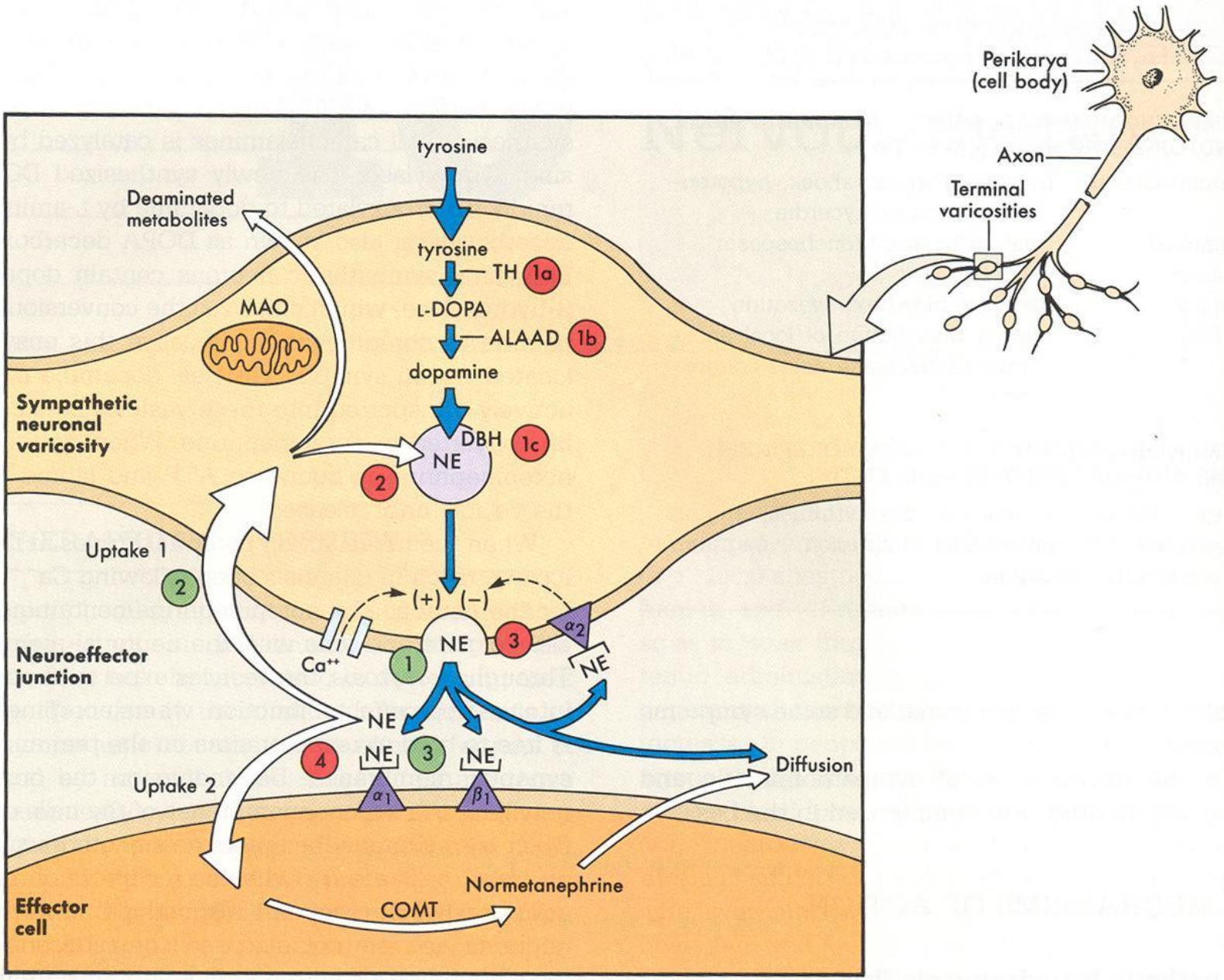


FIGURE 10-1 Prejunctional and postjunctional sites of action of drugs that modify noradrenergic transmission at a sympathetic neuroeffector junction. L-Tyrosine is actively transported into the

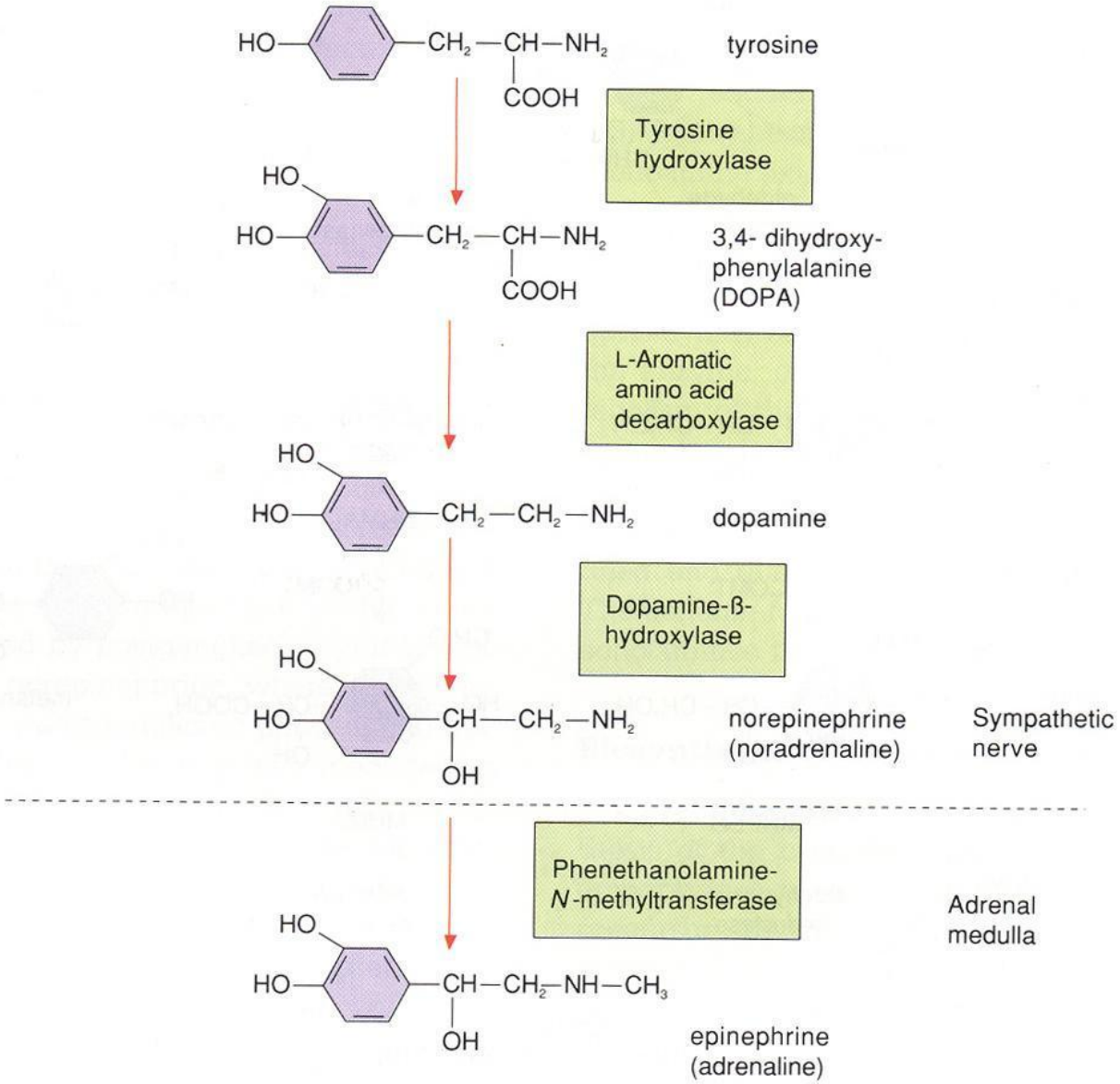


FIGURE 8-4 Steps in the enzymatic biosynthesis of the catecholamines, dopamine, norepinephrine (noradrenaline), and epinephrine (adrenaline). The enzymes involved in each catalytic step are enclosed in boxes. The first three enzymatic steps occur in postganglionic sympathetic nerve terminals leading to the synthesis of norepinephrine, and all four enzymatic steps occur in the adrenal medulla, resulting in the synthesis of epinephrine.

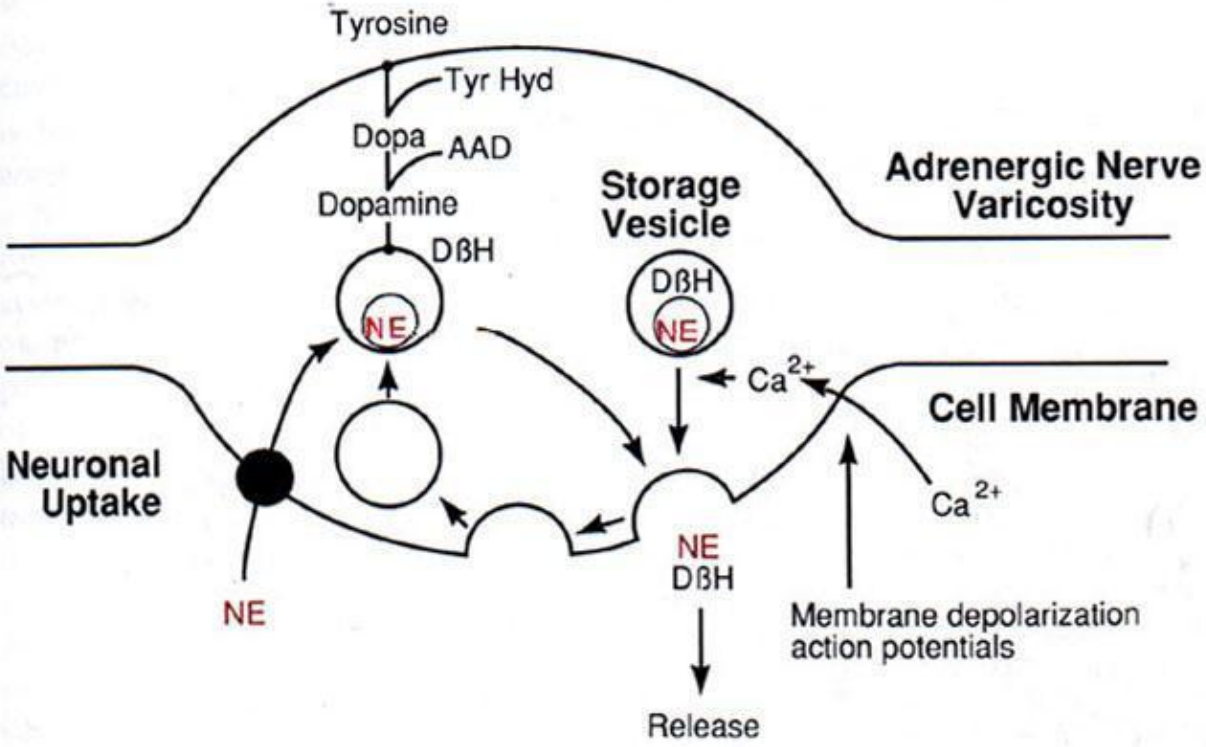


FIG. 4. Synthesis and release of norepinephrine from storage vesicles at sympathetic (adrenergic) nerve varicosities. Norepinephrine uptake is mediated via an active carrier. AAD, aromatic L-amino decarboxylase; DβH, dopamine β-hydroxylase; NE, norepinephrine; Tyr Hyd, tyrosine hydroxylase. (Modified from ref. 2.)

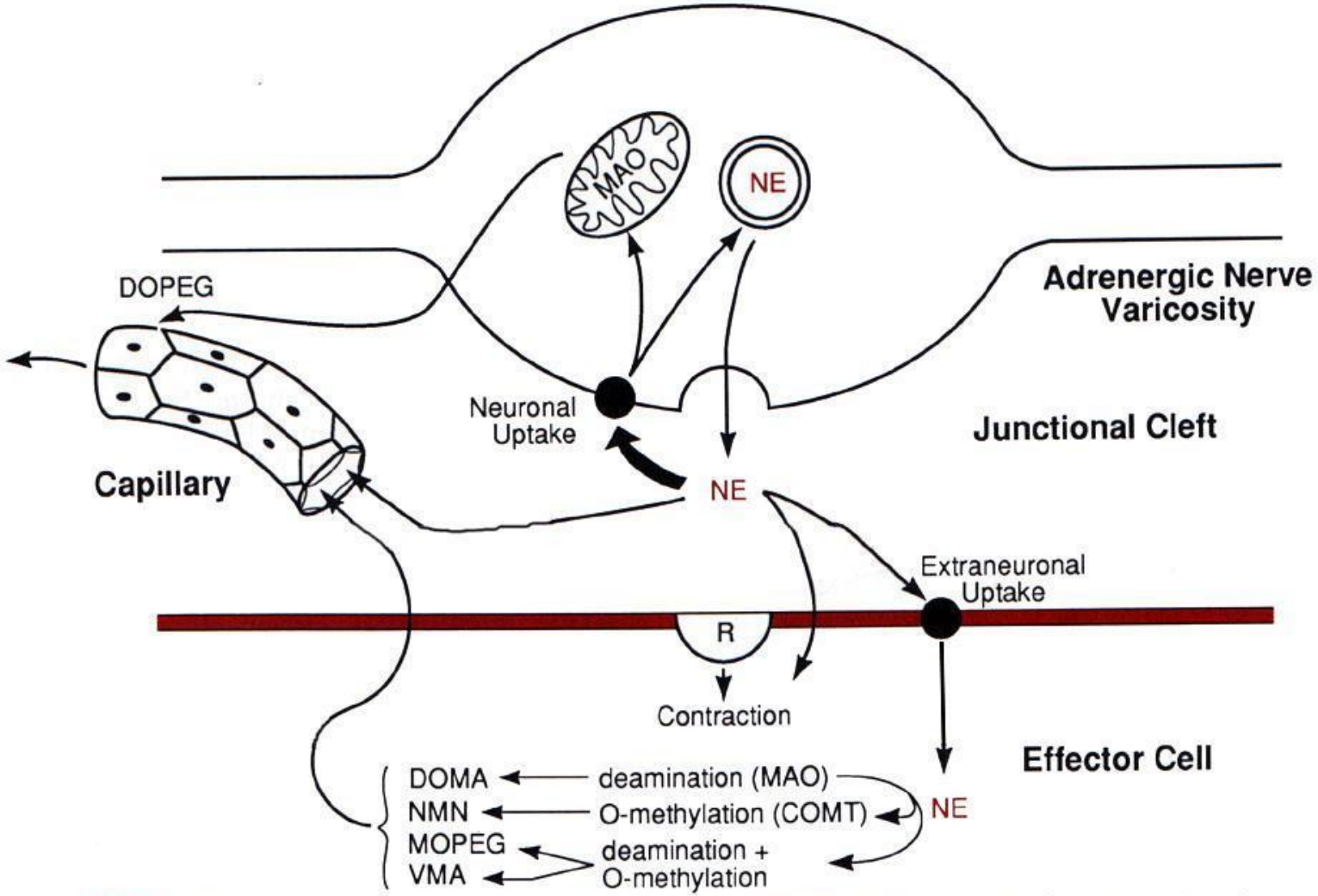


FIG. 6. Mechanisms affecting the concentration of norepinephrine (NE) within the junctional cleft available for binding to a receptor (R) on an effector cell. Norepinephrine is removed by (a) neuronal uptake, in which some is degraded by monoamine oxidase (MAO) to 3,4-dihydroxyphenylglycol (DOPEG), but most is restored in vesicles; (b) diffusion into capillaries; and (c) uptake into effector cells and subsequent degradation by the enzymes MAO and catechol-O-methyltransferase (COMT) to 3,4-dihydroxymandelic acid (DOMA), normetanephrine (NMN), 3-methoxy-4-dihydroxyphenylglycol (MOPEG), and 3-methoxy-4-hydroxymandelic acid (VMA). These metabolites are inactive and diffuse into the extracellular fluid and the capillaries. Neuronal uptake of norepinephrine is mediated by an active carrier.

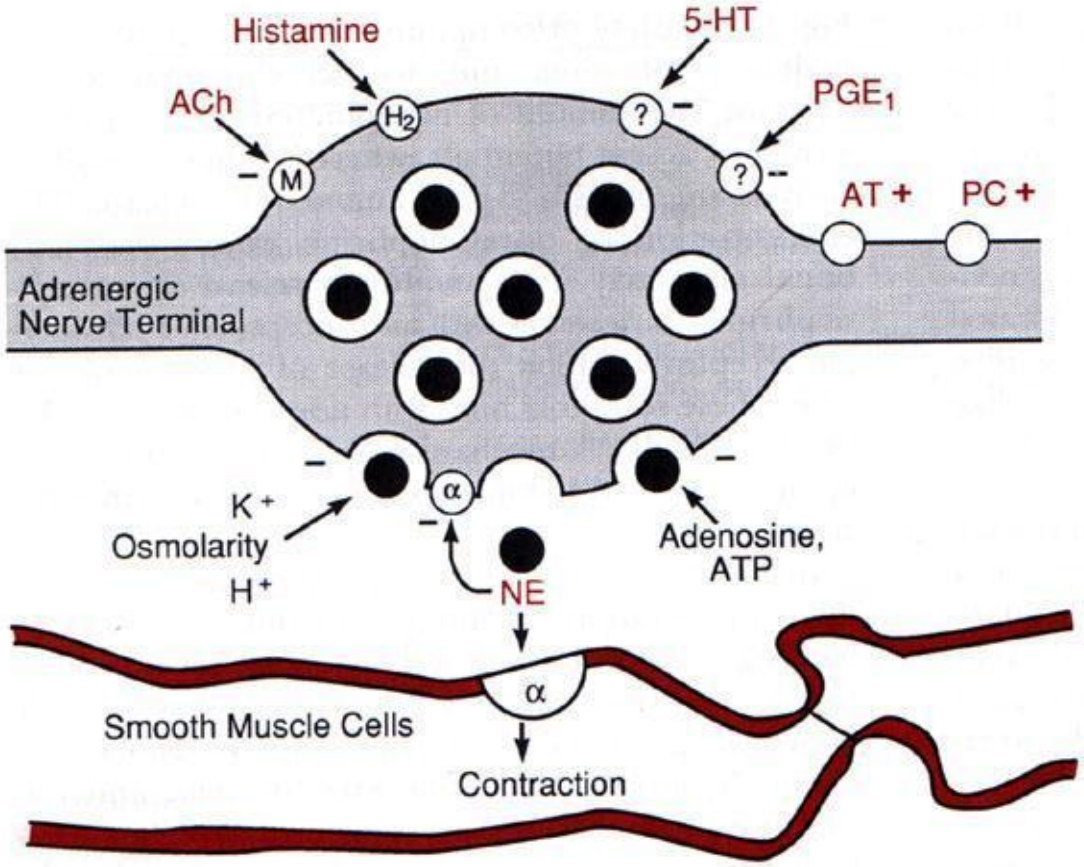


FIG. 5. Various excitatory (+) and inhibitory (−) receptor mechanisms located on sympathetic varicosities. ACh, acetylcholine; α, alpha-adrenergic receptor; AT, angiotensin II; H_2, histamine$_2$ receptor; 5-HT, 5-hydroxytryptamine; M, muscarinic; NE, norepinephrine; PC, prostacyclin; PGE_1, prostaglandin E_1; ?, unknown mechanism. (Modified from ref. 1.)

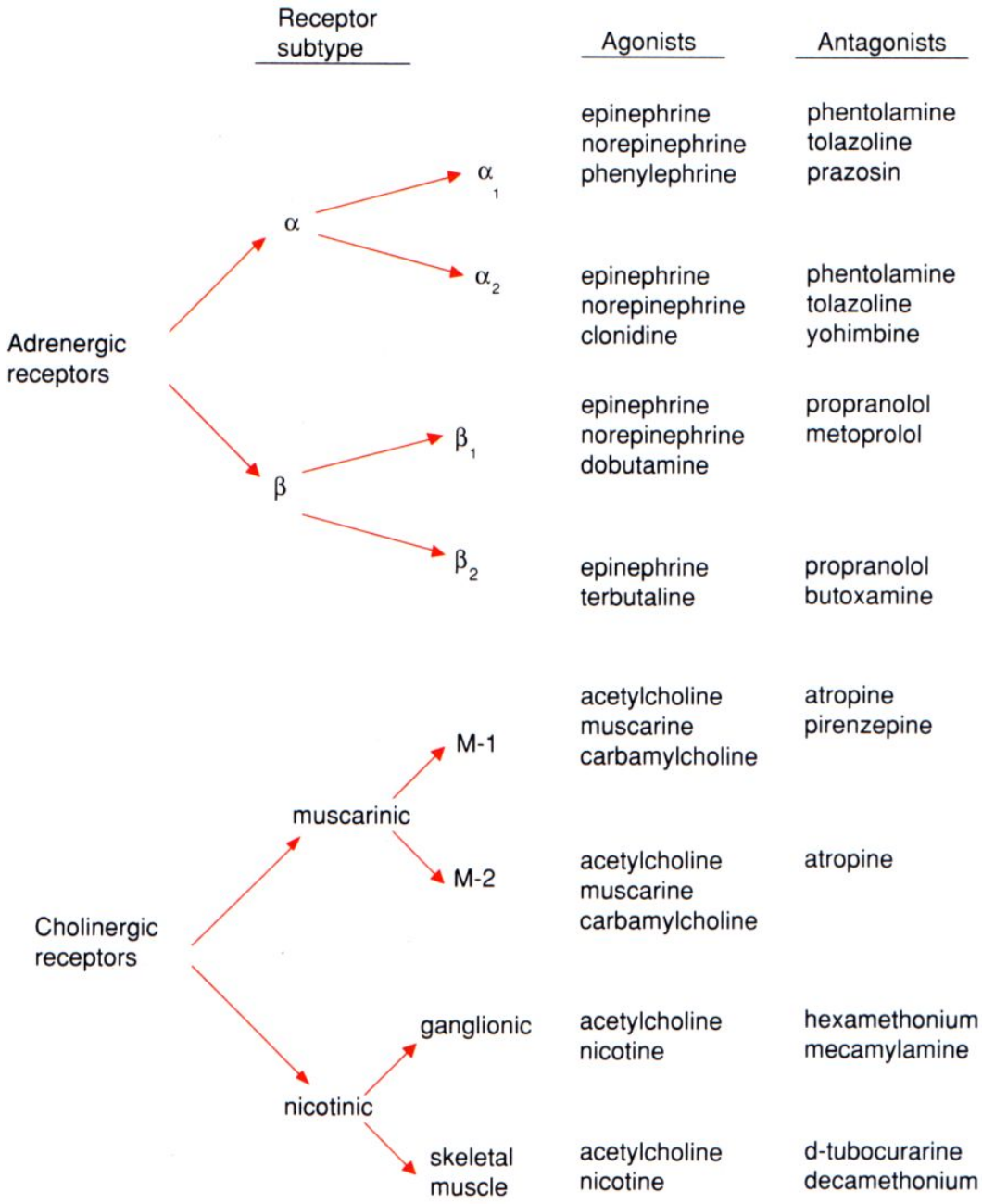


FIGURE 8-6 Division of the adrenergic receptors and cholinergic receptors into individual receptor subtypes. Some of the drugs that stimulate (agonists) or block (antagonists) each of the individual adrenergic and cholinergic receptor subtypes are listed.

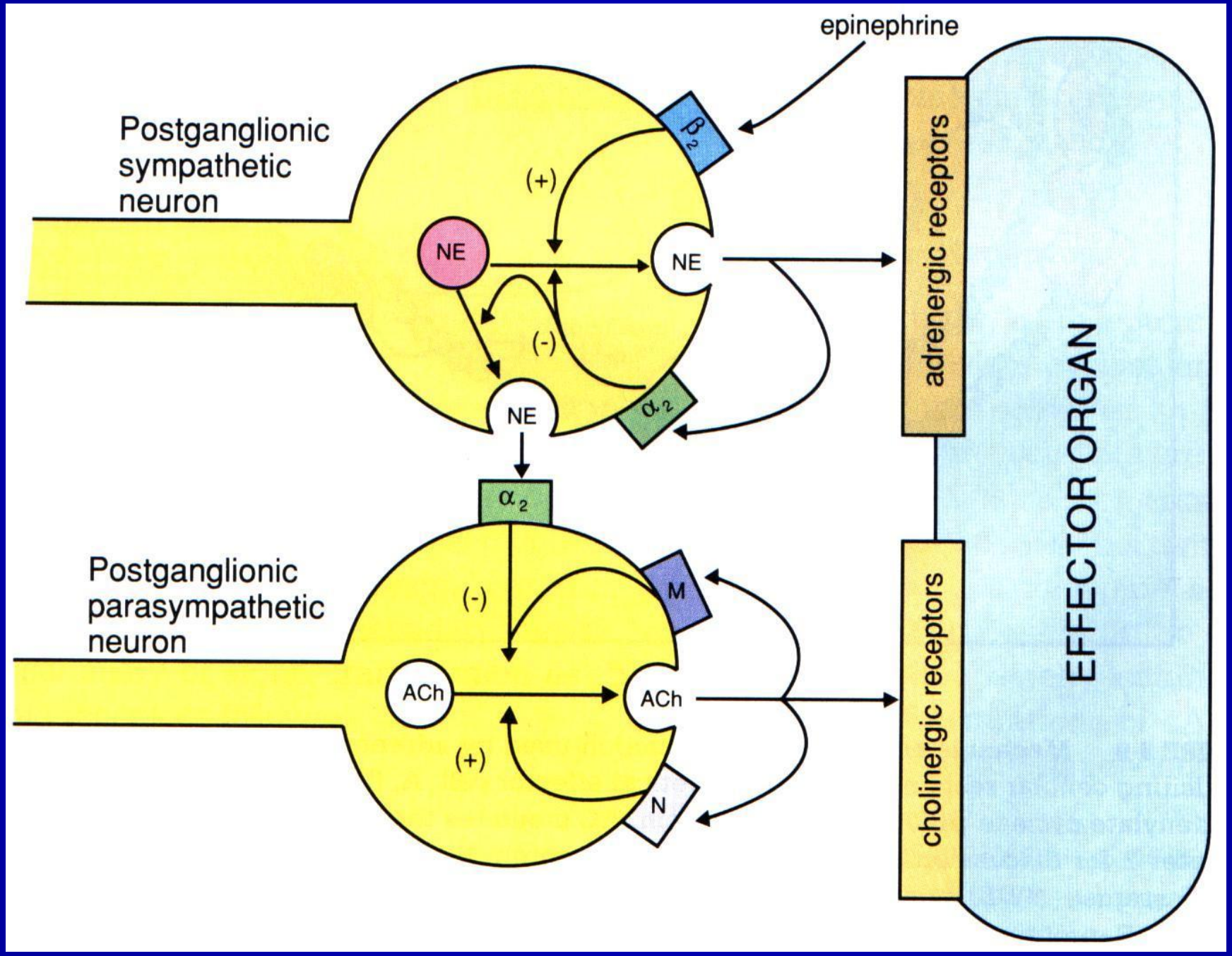
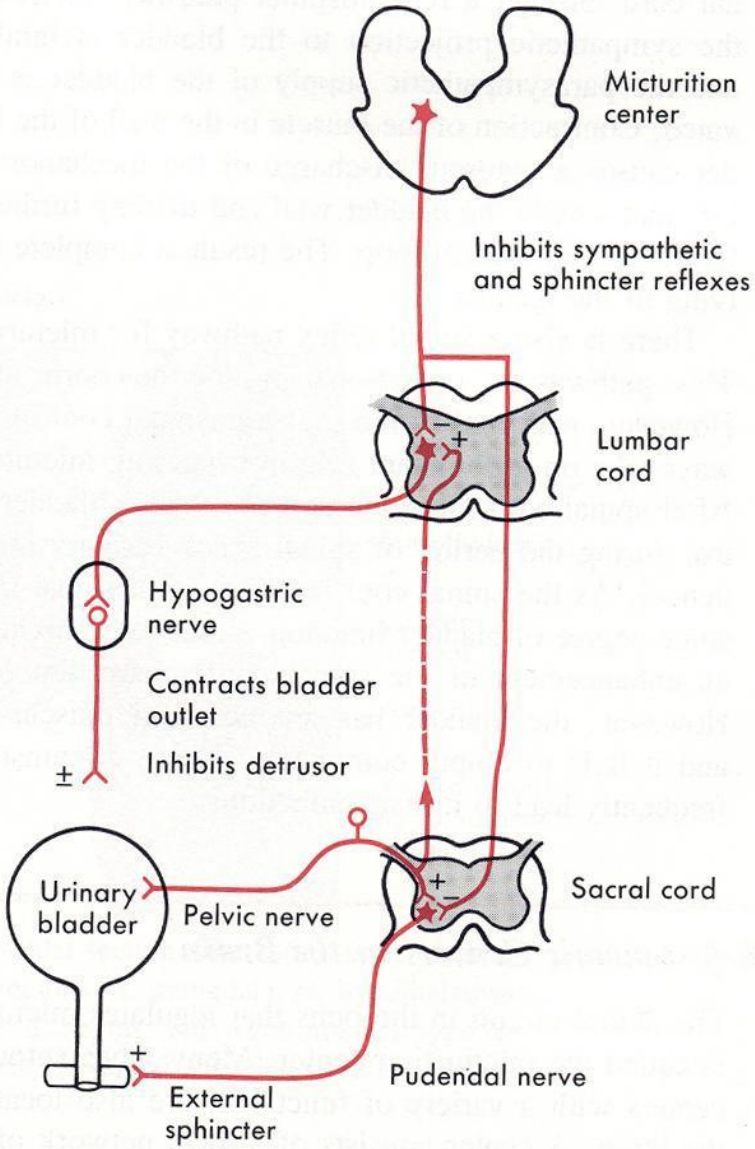

epinephrine
Postganglionic sympathetic neuron
NE
NE
NE
(+)
(-)
β_2
α_2
α_2
adrenergic receptors
Postganglionic parasympathetic neuron
ACh
ACh
(-)
(+)
M
N
cholinergic receptors
EFFECTOR ORGAN

Table 8-1 Responses Elicited in Effector Organs by Stimulation of Sympathetic and Parasympathetic Nerves

Effector Organ	Adrenergic Response	Receptor Involved	Cholinergic Response	Dominant Response* A or C
Heart				
Rate of contraction	Increase	β_1	Decrease	C
Force of contraction	Increase	β_1	Decrease	C
Blood vessels				
Arteries (most)	Vasoconstriction	α_1	—	A
Skeletal muscle	Vasodilation	β_2	—	A
Veins	Vasoconstriction	α_2	—	A
Bronchial tree	Bronchodilation	β_2	Bronchoconstriction	C
Splenic capsule	Contraction	α_1	—	A
Uterus	Contraction	α_1	Variable	A
Vas deferens	Contraction	α_1	—	A
Prostatic capsule	Contraction	α_1	—	A
GI tract	Relaxation	α_2	Contraction	C
Eye				
Radial muscle, iris	Contraction (mydriasis)	α_1	—	A
Circular muscle, iris	—		Contraction (miosis)	C
Ciliary muscle	Relaxation	β	Contraction (accommodation)	C
Kidney	Renin secretion	β_1	—	A
Urinary Bladder				
Detrusor	Relaxation	β	Contraction	C
Trigone and sphincter	Contraction	α_1	Relaxation	A,C
Ureter	Contraction	α_1	Relaxation	A
Insulin release from pancreas	Decrease	α_2	—	A
Fat cells	Lipolysis	β_1	—	A
Liver glycogenolysis	Increase	α_1	—	A
Hair follicles, smooth muscle	Contraction (piloerection)	α_1	—	A
Nasal secretion	—		Increase	C
Salivary glands	Increase secretion	α_1	Increase secretion	C
Sweat glands	Increase secretion	α_1	Increase secretion	C



■ **Fig. 15-4** The pathway for the reflexes that control the urinary bladder. (Redrawn from de Groat WC, Booth AM: *Autonomic systems to bladder and sex organs*. In Dyck PJ et al, editors: *Peripheral neuropathy*, ed 2, Philadelphia, 1984, WB Saunders.)

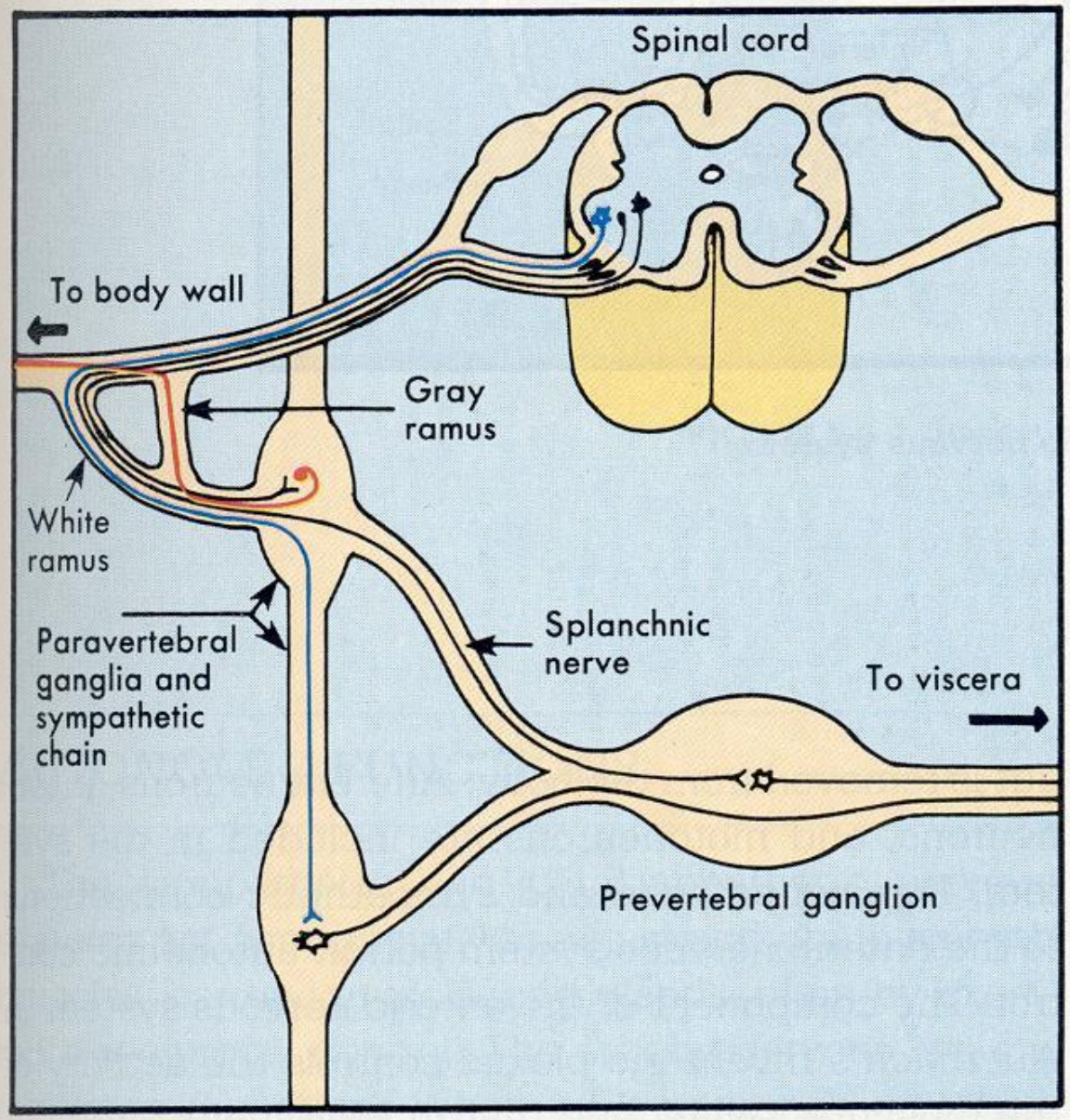


FIGURE 9-1 Distribution of sympathetic preganglionic projections to para- and prevertebral ganglia.

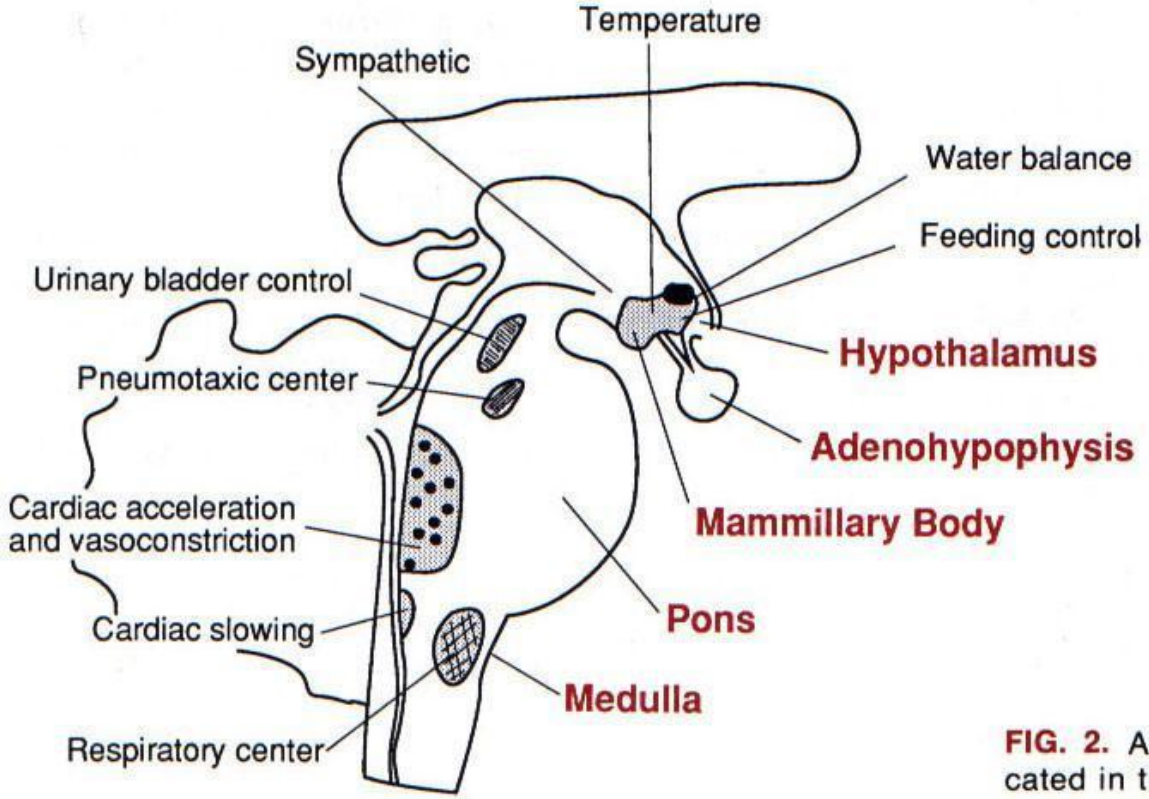


FIG. 2. Autonomic control centers located in the brain stem.

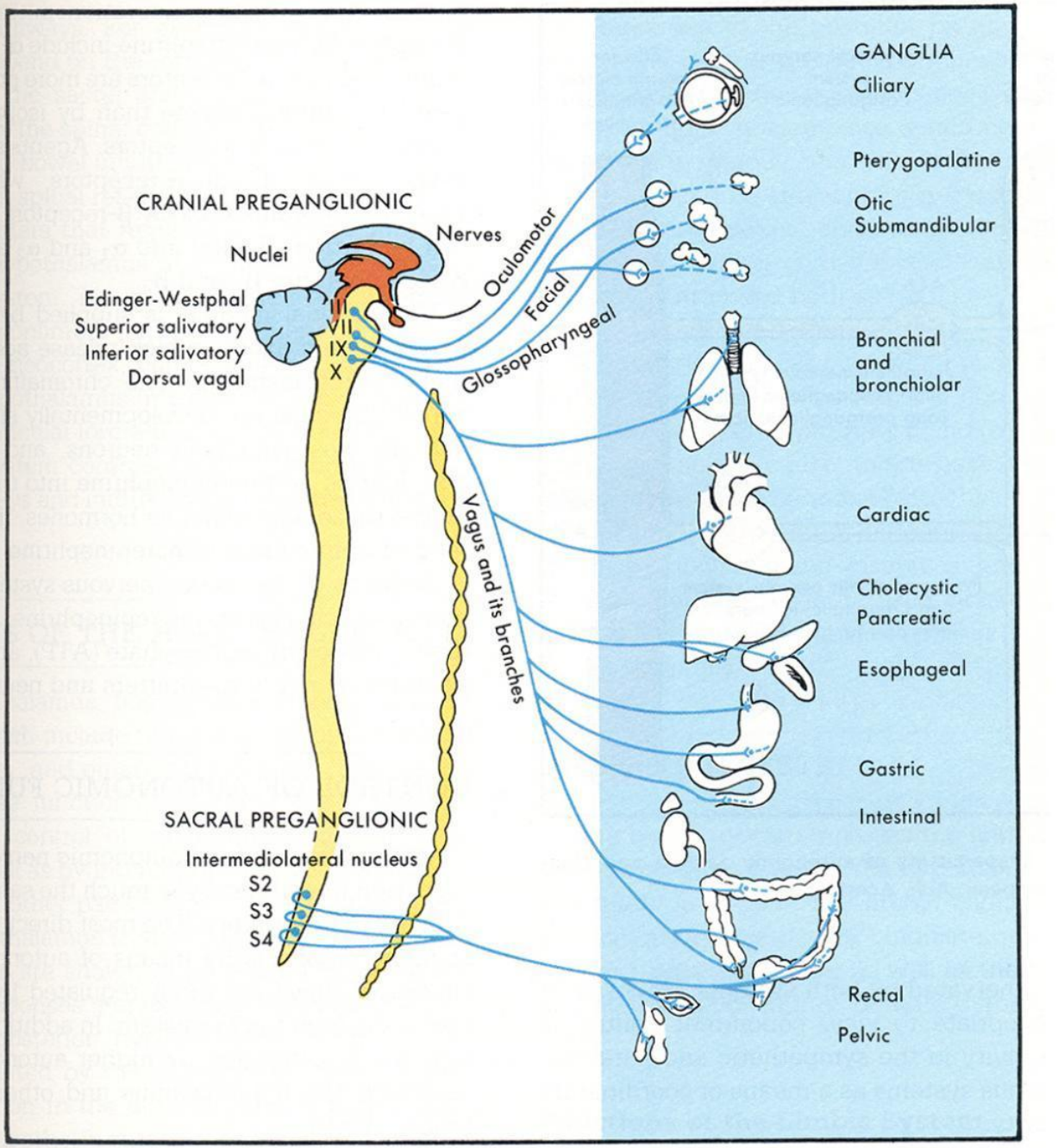


FIGURE 9-3 Parasympathetic nervous system.

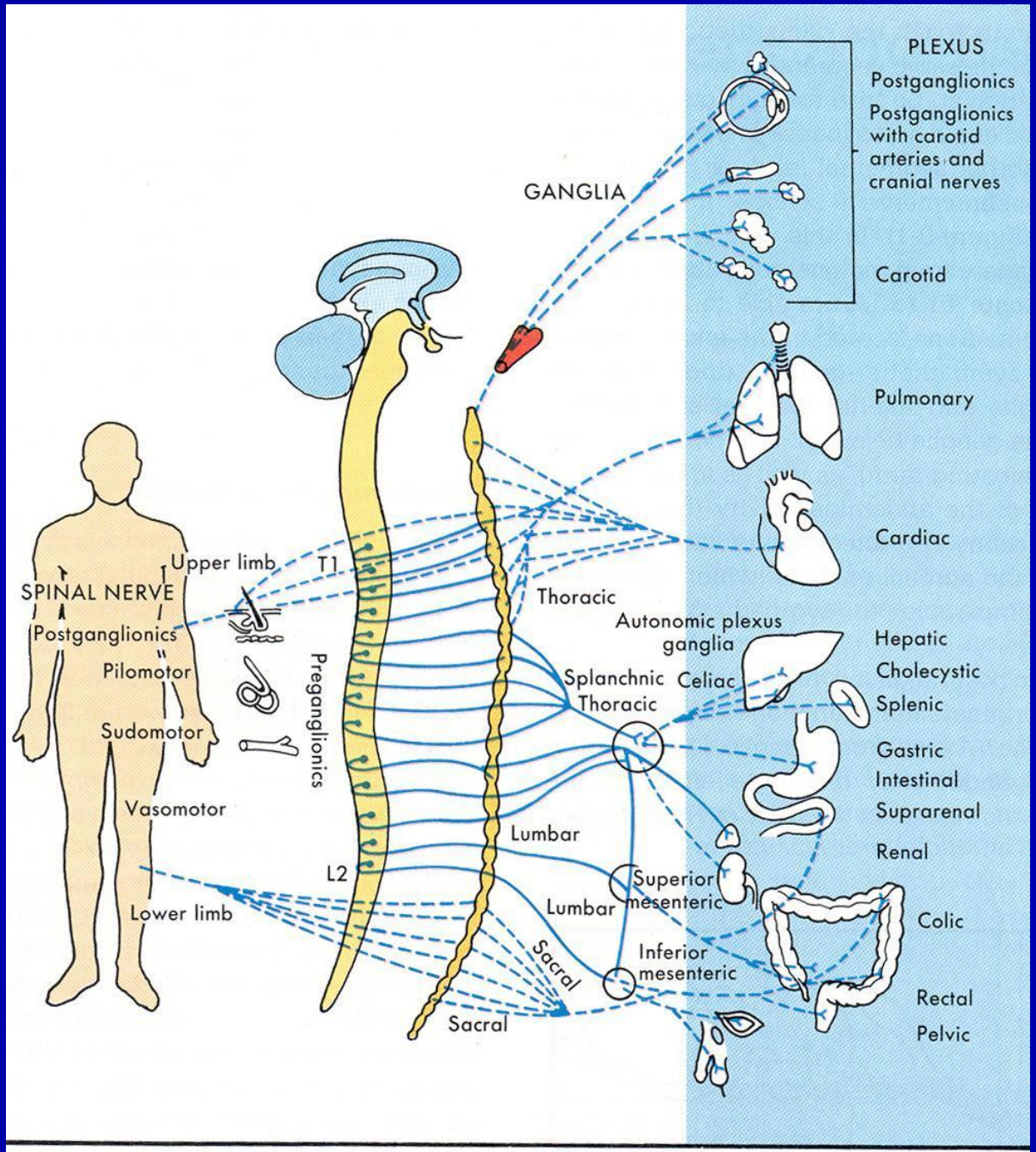


FIGURE 9-2 Sympathetic nervous system.